The Moon: Physical characteristics

Mass = $7.347 \times 10^{22}$ kg

Radius = 1,738 km

Density = 3,344 kg/m³

Sidereal rotation period = 27.32 d

Albedo = 0.11 (Earth = 0.39)

Orbit inclination = 5.15 degrees to ecliptic
Earth & Moon

Moon diameter =
0.27 x Earth diameter

Earth-Moon distance
= 380,000 km
= 30 x Earth diameter
The Moon: Key Concepts

(1) The Moon’s surface has both smooth maria and cratered highlands.

(2) The surface was shaped by heavy bombardment, followed by lava floods.

(3) The Moon has a thick crust but a tiny iron-rich core.

(4) The Moon may have been ejected when a protoplanet struck the Earth.
The Moon’s surface has both smooth maria and cratered highlands.

Dark regions: maria
[singular = mare]

Light regions: highlands (terrae)
Maria are darker in color, lower and relatively free of craters.

Highlands are lighter in color, higher, and heavily cratered. Extend to several kilometers above average.
Maria are concentrated on the near side of the Moon. Why?
Craters on the Moon formed by the impact of meteoroids (they are not volcanic craters). The origin of lunar craters was subject of very intense debate until 1960’s. The Moon has about 100,000 craters over 1 kilometer across; the Earth has many fewer. No atmosphere of liquid water on the Moon; thus, little erosion.
Eugene Shoemaker (1928-1997)

He was one of the founders of the fields of planetary science. Best known for co-discovering the Comet Shoemaker-Levy 9. He has done more than any other person to advance the idea that sudden geologic changes can arise from asteroid strikes and that such strikes are common over geologic time periods.
Earth’s surface: shaped by plate tectonics and erosion.

Moon’s surface: shaped by impact craters and lava floods.
Apollo Missions to the Moon (1969-1972) Brought back 382 kg of rocks for chemical analysis, radioactive dating.
Results of chemical analysis and radioactive age dating of the Apollo moon rocks:

**Maria:** dense basalts 3.1-3.8 billion years old.

**Highlands:** low-density “anorthosite” 4.0-4.5 billion years old.
The Moon’s surface was shaped by heavy bombardment followed by lava floods.

4.5-3.8 billion years ago: Heavy bombardment by planetesimals, cratering of highlands.

3.8-3.1 billion years ago: Lava flows up through cracks, flooding low-lying maria with basalt.

3.1 billion years ago-NOW: No more lava flows, decreasing bombardment.
Moon: 3.8 billion years ago

Heavy cratering, including huge "impact basins".
Moon: 3.1 billion years ago

Impact basins flooded with lava to form smooth maria.
(3) The Moon has a thick crust but a tiny iron-rich core.

Seismometers left on the Moon revealed a number of mild “moonquakes”.

- Crust thinner on near side.
- Thick unbroken lithosphere.
- Small central iron-rich core.
Internal structure of the Moon

- Thicker crust on the far side explains why there are no maria on the far side.
- Thick unbroken lithosphere – no plate tectonics, no major moonquakes (“geologically dead”).
- No liquid core, very slow rotation – no magnetic field now. (But there was a weak one billions of years ago.)
(4) The Moon may have been ejected when a protoplanet struck the Earth.

How did the Earth get such a big satellite??

Of 7 giant moons, only one orbits a terrestrial planet.

Of 4 terrestrial planets, only one has a giant moon.

Many hypothesis have been proposed, then shot down.
FISSION Hypothesis

Moon was “spun off” from the rapidly spinning young Earth.

Oops:

• Moon is NOT in the Earth’s equatorial plane.
• Moon’s crust has fewer volatile elements (such as potassium, sodium) than the Earth’s crust.
CAPTURE Hypothesis

Moon formed elsewhere in the Solar System, came near the earth, and was gravitationally captured.

Oops:

- To go from an orbit around the Sun to an orbit around the Earth, the Moon would have to lose lots of energy.
- Rocks are too similar.
CO-CREATION Hypothesis

Moon formed from planetesimals in the vicinity of the Earth.

Oops:

- Moon has tiny iron core (3% of mass), Earth has a large core (32%): Why did the Earth get all the iron?
- Why no large moons for other terrestrial planets?
Current favorite:

COLLISIONAL EJECTION THEORY

A protoplanet the size of Mars struck the young Earth an oblique blow, just over 4.5 billion years ago.
Computer simulation of impact:

**Mantle** of the colliding body was ejected to form the Moon.

**Iron core** of the colliding body sank to the Earth’s center.
This dramatic collision likely happened when Earth was almost completely formed. Age of the Moon almost as old as the age of the oldest meteorites:

- Age of oldest Earth rocks = 4 billion years
- Age of oldest Moon rocks = 4.5 billion years
- Age of oldest meteorites (meteoroids that survive the plunge to Earth) = 4.56 billion years
Few closing questions:

1) Name the major differences between Earth and Moon.
2) Is there still volcanic activity on the Moon?
3) How dense is the atmosphere of the Moon?
4) Is there water on the Moon?
5) Why are there moonquakes?
6) Any other consequences of the Moon formation?